San Joaquin River MP and the SJVDIP are two inter-agency programs that encourage implementation of in-valley drainage measures.

Reuse

The SJVDIP identified three forms of agricultural drainage reuse: recycling, blending, and sequential reuse. These methods reduce the volume of drainage water discharged to surface waters or even eliminate these discharges when combined with salt treatment, storage, or transport options. Relatively high-quality surface agricultural runoff could be reused with on-farm recycling and blending with other supply water to irrigate crops with low salt tolerance. More saline or unblended waters could be sequentially reused on salt-tolerant crops. Still more saline subsurface agricultural discharges could be collected and used for irrigation of salt-tolerant trees and halophytes (see "Integrated On-Farm Drainage Management" discussion below). Residual brines, while much decreased in volume, still would need to be processed through the combination of producing distilled water, evaporation of remaining water, salt recovery, and salt handling.

Drainage water reuse by blending and recycling will increase the concentration of salts in soils, which will adversely affect crop yield. Sequential reuse of drainage water is needed to enhance and sustain land productivity. If not properly managed, deep percolation of the concentrated salts could affect groundwater quality.

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As with source control and drainage reduction, adequate data are available from the SJVDIP and UC Salinity/Drainage Program to evaluate the feasibility and effectiveness of reuse methods.

Reverse Osmosis

Reverse osmosis is potentially a useful means of removing salts and trace elements from agricultural drainage water so that the water can be used as agricultural or other supply. Residual salts still would need to be used, stored, marketed, or disposed of. Reverse osmosis methods do not currently appear feasible due to high costs, although continuing research suggests costs could be reduced. Reverse osmosis may be economically justifiable if it produces salt and water as marketable commodities. The progress of reverse osmosis research and development efforts should be monitored by CALFED.

Cogeneration

Waste heat from thermal generation of energy could be used to further concentrate saline drainage water and produce distilled water. Residual salts still would need to be used, stored, marketed, or disposed of. Cogeneration methods do not currently appear feasible due to high costs but are subject to further research and development. Cogeneration may be economically justifiable if it produces salt and water as marketable commodities.

Integrated On-Farm Drainage Management

Integrated on-farm drainage management systems sequentially reuse drainage water to produce salt-tolerant crops and tree biomass, and concentrate the salinity of residual brines. Integrated on-farm drainage management systems operate on the principle that drainage water, salt, and selenium are resources of economic value. This concept distinguishes integrated on-farm drainage management from other drainage management approaches that view drainage water only as waste to be reduced and salt to be discharged. Residual salts would be used, stored, marketed, or disposed of. This approach has significant potential to reduce the discharge of salts to the San Joaquin River, thus improving salinity in the river and the Delta. This action requires installation of tile drains in the problem area; collection of drainage water; and sequential reuse on more salt-tolerant crops and plants, followed by discharge of brine to solar evaporators or other salt-recovery facilities. This approach is a practical method of in-valley drainage and salt management.

Integrated on-farm drainage management systems operate on the principle that drainage water, salt, and selenium are resources of economic value.

Integrated on-farm drainage management systems must be managed in a way that prevents access of wildlife to potential sources of selenium. Evaporation ponds, which differ significantly from solar evaporators, can affect wildlife and the mitigation costs can be prohibitive. Wildlife safety is accomplished with minimal water ponding, combined with hazing. The objective of integrated on-farm drainage management is to substantially reduce drainage water, salts, and selenium discharged from farms into rivers and other water bodies.

Solar evaporators use only about 0.3% of the farmland area, which is a fraction of the land required by evaporation ponds (about 10% of the farmland). Evaporation ponds contain a few feet of standing water, while solar evaporators have no standing water or a fraction of an inch of water for a limited time.

Trees are a component of integrated on-farm drainage management systems that could create wildlife habitats in the otherwise nearly treeless environment of the San Joaquin Valley. New habitats could enhance the ecological quality of irrigated farmland for the benefit of both agriculture (integrated pest management) and wildlife. In addition to providing windbreaks for crops and structures, trees also improve air quality.

Trees are a component of integrated on-farm drainage management systems that could create wildlife habitats in the otherwise nearly treeless environment of the San Joaquin Valley.

Where concentration of selenium in drainage water is high, the integrated on-farm drainage management approach (similarly to other methods) may result, if not properly managed, in significant impacts on waterfowl. However, the integrated on-farm drainage management approach separates selenium flows from waterfowl by controlling the volume of water discharged into a solar evaporator to eliminate water ponding. Consequently, the solar evaporator does not attract waterfowl. The small area of a solar evaporator provides for efficient hazing, which further enhances wildlife safety.

The San Joaquin Valley growers are interested in this integrated on-farm drainage management system and view it as a practical farming method for managing salinity. As with any drainage management method, adequate leaching of salts to maintain soil productivity is a necessity and must also be an essential component of an integrated on-farm drainage management system. Deep percolation of concentrated salts, if not managed, could affect groundwater quality.

On-farm and districtwide source control, drainage reduction, and reuse should continue to be encouraged. Investigation of integrated on-farm drainage management, sequential drainage reuse, selection of salt-tolerant plants and trees, management of wildlife habitats, and salt and selenium separation concepts should continue. Potential uses of and markets for salt should be investigated. Additional demonstration projects and training programs for integrated on-farm drainage management systems should be developed.

Where concentration of selenium in drainage water is high, the integrated on-farm drainage management approach (similarly to other methods) may result, if not properly managed, in significant impacts on waterfowl.

Integrated on-farm drainage management and solar evaporators are being tested for their adequacy and operational feasibility in the San Joaquin Valley. Salt separation from drainage water is feasible, but salt purification and marketing requires additional studies. Presence of dust particles and trace elements may naturally affect the use of any salt, but this can be prevented by using appropriate salt recovery methods. Further research and development are needed on:

- The selection of salt-tolerant plants and trees;
- Complete utilization of drainage water through sequential reuse and solar distillation;
- Distillation (using solar or other sources of energy);
- Salt recovery, utilization, and marketing;
- Management of wildlife habitats;
- Sustainability of agriculture and environment; and

- Management of solar evaporators to assure protection of wildlife and groundwater.

Existing Activities

Source Control and Drainage Reduction

The California Agricultural Water Management Planning Act requires all agricultural water suppliers delivering over 50,000 acre-feet of water per year to prepare an Information Report and identify whether the district has a significant opportunity to reduce drainage water volume through improved irrigation techniques. An MOU regarding efficient water MPs by agricultural water suppliers in California was signed in May 1997. This MOU provides a mechanism for planning and implementing cost-effective water MPs.

The SJVDIP continues to promote source control as one in-basin method to reduce salt loading in the San Joaquin Valley. Much work in this area has already been done under the guidance of the CVRWQCB through drainage operation plans.

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Additional increases in efficiency were realized associated with selenium load limitations imposed by the Grassland Bypass Project. Mechanisms such as tiered water pricing, low-interest loans, and other economic incentives have contributed to these increased efficiencies by Grassland Area Farmers. These increased efficiencies have greatly reduced and, in some cases, eliminated surface return flows but have only slightly reduced subsurface drainage. The Grassland Bypass Project is an example of a successful program that has improved water quality. The project enables the rerouting of agricultural drainage from a 97,000-acre area away from wetlands supply channels and into Mud Slough (and, ultimately, the San Joaquin River) via part of the San Luis Drain. The discharge, governed by a Use Agreement between the San Luis and Delta-Mendota Water Authority and Reclamation is subject to WDRs issued by the CVRWQCB, which set limits on selenium discharges. The local water districts affected by the project formed a regional drainage district, enabling the growers to work together to reduce drainage and collectively manage and reduce selenium loads. While the project primarily has emphasized selenium management, the efforts of the Grassland Area Farmers also have led to reductions in the discharge of salts and boron from the area.

As a result of the Grassland Bypass Project, the amount of salt, boron, and selenium discharged by Authority members within the Grasslands area has been significantly reduced. In the 1999 water year, salinity was reduced by 32%, boron by 14%, and selenium by 48% of the historical levels of similar water-year types. These reductions should be discussed in the Water Quality Program, and the Grassland Bypass Project may be further developed as an element of the Water Quality Program Plan.

Opportunities for drainage management in the Delta also should be explored. Improvement in water use efficiencies in agriculture has been accomplished in various areas. More opportunities still exist.

Reuse

Reuse is a key element of the SJVDIP recommendations for drainage management. The intent of drainage reuse is to improve irrigation water use efficiency, hence reducing the volume of drainage requiring disposal. A simple drainage reuse increases soil salinity, however, and it prevents creating sustainable environmental and agricultural systems. In some cases, reuse of drainage cannot be accomplished without installation of tile drains. This action requires the installation of subsurface recirculation systems that can require substantial plumbing of the existing system. Reducing drainage water by reuse requires the installation of on-farm tile drainage for existing croplands and for salt-tolerant tree and halophyte plantings to enhance evapotranspiration. A total of 3,500 acres was recommended for drainage reuse in the Grassland area by 2000.

Reuse is a key element of the SJVDIP recommendations for drainage management.

Studies have continued based on proposals by the SJVDIP. Grassland Area Farmers were able to reduce salt loads discharged into the Grassland Bypass Project by 32% from previous years as a result of recirculation and other activities. Research on the potential for phytoremediation and volatilization of selenium in an agricultural drainage reuse system setting is continuing. Sequential reuse systems, in combination with water cycling or blending, are basic components of integrated on-farm drainage management systems currently being tested on several farms in the San Joaquin Valley.

Integrated On-Farm Drainage Management

Integrated on-farm drainage management has been practiced on several farms in the San Joaquin Valley. The Westside RCD manages experimental and demonstration projects. State and federal agencies and universities continue to develop and evaluate integrated on-farm drainage management systems. These activities include the management of drainage water, salt harvesting in a solar evaporator, salt processing, solar distillation of drainage water, the selection of trees and plant crops for highly saline conditions, and management of wildlife habitat. DWR, working with other agencies, districts, and growers, is developing integrated on-farm drainage management components. Management schemes are

Integrated on-farm drainage management has been practiced on several farms in the San Joaquin Valley.

being developed to assess the long-term viability of integrated on-farm drainage management. Research and demonstration projects are focusing on:

- Long-term maintenance of soil conditions that ensure growth of trees and halophytes using high salt/boron content drainage water for irrigation.
- Identification of adverse wildlife impacts associated with integrated on-farm drainage management's irrigating with drainage water containing selenium and prevention of those impacts.
- Development of agronomic design and management of integrated on-farm drainage management to improve evapotranspiration, growth, and sustainability.
- Recovery or use and marketability of salts.

7.5.2 *Basinwide Actions*

Basinwide actions discussed below include water quality objectives, the quality of supply, real-time management, recirculation of DMC water, and salt disposal.

Priority Actions

Water Quality Objectives

Water quality objectives are set by the RWQCB to ensure protection of beneficial uses of a surface water. The RWQCB could use its regulatory authority to establish water quality objectives on the main stem San Joaquin River in the 130-mile segment that is listed on the CWA Section 303(d) list as impaired. Should corrective actions not result in achieving those water quality objectives, the RWQCB could develop TMDL allocations for affected water bodies, which would provide regulatory incentive for implementation of further actions to meet objectives. Use of financial incentives, such as grants, low-interest loans for drainage reuse, tiered water pricing, and establishment of demonstration projects, should be considered.

Use of financial incentives, such as grants, low-interest loans for drainage reuse, tiered water pricing, and establishment of demonstration projects, should be considered.

- **Recommended actions:** CALFED should support establishment of water quality objectives, development and implementation of BMPs, development of TMDLs (as necessary), and financial incentives for salt control.

Improved Quality of Supply

Improved quality of water supply, specifically for water imported from the Delta, would result in lower salt concentrations of surface and subsurface drainage. Over the short term, salinity of surface runoff would be lower because of the direct effect of supply water quality on surface runoff. Salinity of surface return flows typically increase slightly above levels of the irrigation supply water. Over the longer term, the quality of subsurface drainage would improve and the quantity would be reduced because of the decreased need for leaching of salts in the root zone. Approaches to improving the quality of source water to the San Joaquin Valley would include reducing salts in Delta water by improving water quality through conveyance alternatives, such as isolated facility or through-Delta improvements, relocation of drainage from the Delta islands, and south Delta and Delta Region circulation barriers.

Improved quality of water supply, specifically for water imported from the Delta, would result in lower salt concentrations of surface and subsurface drainage.

South Delta barriers would improve water quality in some south Delta channels (although possibly worsen water quality in other channels) and thus improve water for Delta agriculture and export uses south of the Delta. South Delta barriers also could affect other urban users taking water from the central Delta. DWR's ISDP is designed to comply with all regulatory standards, including the salinity objectives in the May 1995 SWRCB WQCP for the Delta. Therefore, the operation of ISDP is not expected to result in significant adverse impacts due to non-compliance with any salinity standards. However, any increases in salinity at export facilities may result in additional treatment costs, which could be considered a significant adverse impact, even if the WQCP standards are being met.

South Delta barriers would improve water quality in some south Delta channels (although possibly worsen water quality in other channels) and thus improve water for Delta agriculture and export uses south of the Delta.

ISDP operational changes required to avoid potential adverse impacts on protected fish and wildlife positively affect water quality. Consequently, ISDP is currently reevaluating its salinity impacts, based on revised operating criteria resulting from ongoing Endangered Species Act (ESA) consultation.

Reducing salt import to the area of use should be considered. This action item includes south Delta barriers, intake relocation for urban users, discharge reduction or relocation for some Delta agricultural drainage, and the DMC circulation proposal. South Delta barriers can be used to manage drainage flows, tidal currents, and stages in the San Joaquin River, Middle River, and inter-connecting channels. However, the impact of flow barriers on the quality of source water for CCWD and in-Delta users should be evaluated. One approach would be to investigate relocation of discharge points in the Delta away from source water intakes. Drainage discharge reduction in Old River and drainage reduction into Rock Slough will help improve water quality at CCWD intakes.

Reducing salt import to the area of use should be considered.

- **Recommended actions:** Identify drainage reduction measures for Delta islands, identify potential drainage discharge relocation projects, and study water quality benefits and ecological effects of south Delta barriers.

Real-Time Management

This approach proposes to actively manage the assimilative capacity of the San Joaquin River by controlling discharge of salts from agriculture and wetlands through an inter-agency program of real-time water quality management. The assimilative capacity of a water body is defined as the mass of a contaminant that a receiving water can accept without violation of the concentration limit for that contaminant, at a given rate of discharge of both source and receiving water bodies.

Opportunities for adjusting the timing of discharges and reservoir releases have been identified, although the practical constraints to such adjustments have not been thoroughly explored. By making such adjustments, temporal variations in water quality can be minimized and the frequency of violation of water quality objectives can be reduced. A real-time water quality management system, along with pollutant load reduction, could allow continued discharge of salt from agricultural lands and wetlands while minimizing impacts on the San Joaquin River and minimizing violations of water quality objectives.

The goal of real-time water quality management is to make multiple use of water that is already being stored or released for other purposes. For example, releases currently are being made from tributaries to the San Joaquin River for the explicit purpose of providing pulse/attraction flows for fish; releases also are being made from New Melones Reservoir for the explicit purpose of providing dilution flows to meet water quality objectives at Vernalis (in accordance with SWRCB Water Rights Decision 1422). Coordination of existing reservoir releases for fish flows with existing discharges of salt can result in reducing overall reservoir releases needed explicitly to provide dilution flows. Real-time management applied in this example would result in water savings but would not reduce salt load to the river. Should dilution flows cease, the real-time management would use the assimilative capacity of the San Joaquin River. The CALFED Program is not requiring new releases of fresh water for dilution but seeks to use what is already available.

The goal of real-time water quality management is to make multiple use of water that is already being stored or released for other purposes.

Real-time management of the river for salinity may involve drainage recycling, which may affect crop yields if root zone salinity is not carefully managed. Short-term surface storage may negatively affect wildlife, if the ponds are poorly designed or if water remains ponded during the wildfowl nesting season. This concept requires close cooperation between agencies without a history of coordinated interaction; consequently, some institution building will be required. Real-time management shifts the temporal distribution of salt loads. Therefore,

Real-time management of the river for salinity may involve drainage recycling, which may affect crop yields if root zone salinity is not carefully managed.

concentrations of salinity could increase during some periods, which may result in an environmental impact.

Previous real-time water quality modeling efforts in the Grassland Basin primarily focused on screening-level assessments of operational constraints on, and opportunities for, agricultural drainage discharges. Reclamation developed a sophisticated planning model that considered several alternatives to meet selenium and boron water quality objectives in the San Joaquin River. The alternatives considered were irrigation improvements, drainage water reuse, land retirement, and the use of holding reservoirs to regulate the release of drainage to the river. These alternatives were optimized to minimize the size of the regulating reservoirs and to ensure that the constraining water quality objective (selenium or boron) was not exceeded.

The results of the modeling analysis suggested that, with investments in drainage recycling facilities and the construction of regulating reservoirs with a total capacity of 4.3 million cubic meters, water quality objectives could be met at all times. The Reclamation model assumed perfect forecast and response to receiving water assimilative capacity and that the water quality of irrigation water and groundwater pumpage remained constant over the simulation period. During the first year of the Grassland Bypass Project, considerable investment was made by water districts in the Grassland Basin in facilities to allow recycling of subsurface drainage water and to prevent co-mingling of tailwater and subsurface drainage water. Sumps were retrofitted with controllers to allow tile drainage systems to be shut down during high rainfall-runoff periods, allowing more control over drainage discharge and mass loading of salts and other contaminants. Continued investment in these types of technologies and adaptive management to continually refine the operation of these systems will be needed to achieve SJVDIP goals.

- **Recommended actions**: Encourage coordination among diverters and dischargers and other beneficiaries of the San Joaquin River, and provide incentives for coordination and implementation of measures that help to manage salinity in the San Joaquin River.

Recirculation of Delta-Mendota Canal Water

A project has been proposed by south Delta stakeholders to temporarily store drainage water from the Grassland area (agricultural drainage and wetlands releases) from March until April 15 and also to circulate DMC water during drainage release from April 16 to May 15. The proponents contend that the project would help to meet the pulse flow requirements at Vernalis, per the 1994 Bay-Delta Accord, and would improve water quality in the south Delta. The circulation of water in the river and the Delta, combined with south Delta barriers, may help to improve water quality in parts of the Delta.

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Utilizing periods of high rainfall runoff, fish flow releases, and other periods of high assimilative capacity in the San Joaquin River has been demonstrated by the San Joaquin River MP-WQS to have potential for reducing violation of water quality objectives at Vernalis. Recirculation of Delta water and discharge at Newman Wasteway or Mendota Pool increase the assimilative capacity of the river for salts and other contaminants, and improve the water quality in the river. Urban water users have voiced concerns on the potential impacts of the proposed circulation on the quality of water in the central Delta and at the intake locations. DMC recirculation requires holding water in wetlands and agricultural lands, which may result in an impact. Circulation of water may affect the fisheries, water supply exports at the SWP and DMC, and water quality in the CCWD intakes. Other issues, such as potential impacts on sediment transport from Newman Wasteway to the river and flooding, have not been studied.

Simulation results indicate that salinity would be reduced at Vernalis during drainage retention periods, and that salinity would not change during periods of circulation and release of drainage water. However, salinity would be reduced during drainage retention and during circulation upstream of Vernalis. If south Delta barriers were operating during circulation, water quality for agricultural use in the south Delta would be improved. This improvement in water quality for the south Delta would result in less salts discharged to the Delta channels. If less salts are discharged to the Delta channels and the Delta outflow is the same, long-term water quality should be improved at the intake location (CVP and perhaps SWP and CCWD intakes). The use of Delta barriers would divert the river water from the south Delta to the central Delta and thus improve the quality of water to agriculture in the south Delta and export uses south of the Delta. At this time, however, the beneficial and adverse impacts of these actions on the water quality at the state and federal diversion points and at the CCWD water intakes are unknown. It appears that the circulation would reduce the fish flow release requirements by about 2,000 acre-feet.

The DMC proposal predicts some improvement in water quality in the river and the south Delta. The next step would be to conduct more studies, including modeling, to identify and evaluate the impacts on fisheries, on the SWP and DMC export, and on water quality for CCWD. Studies also are needed to determine whether such an action would conflict with state and federal policies or laws concerning water quality degradation.

The next step would be to conduct more studies, including modeling, to identify and evaluate the impacts on fisheries, on the SWP and DMC export, and on water quality for CCWD. Studies also are needed to determine whether such an action would conflict with state and federal policies or laws concerning water quality degradation.

- **Recommended actions:** This proposal is controversial because some CALFED agencies believe that such a project could violate state and federal policies against water quality degradation, while other CALFED agencies do not agree. This proposal will need to be formulated in detail to determine whether it would conform to these policies. It is understood that the current configuration of the pumping systems and the conveyance systems may not support such a project and that considerable